IV.—*On some Relations between the Geology of Eastern Maine and New Brunswick.*

By L. W. BAILEY.

(Read May 23, 1888.)

Is is now twenty-six years since the date of publication of Prof. C. H. Hitchcock's Second Report upon the Geology of Maine, a work containing descriptions and accompanied by a map illustrative of the geology of those portions of the State which are adjacent to the Province of New Brunswick. It was at about the same time that, in this latter Province, a renewed interest in its geological structure and history was being awakened by a more careful study of the formations exposed in and near the city of St. John, and the discovery of the remarkable flora and fauna which they contain. These discoveries were at that time made the basis of some interesting comparisons between the geology of St. John and that of south-eastern Maine, especially as regards the plant-bearing beds of the two districts, by Sir Wm. Dawson; but it was not until the year 1868 that, by the extension of the work of the Dominion Geological Survey to the Lower Provinces, anything like a systematic study of the actual border-region between the two countries was begun. With the progress of these investigations in New Brunswick much additional light was necessarily thrown upon the geology of eastern Maine, while actual examinations of the latter were from time to time made, when they seemed likely to be of service to a more correct appreciation of the geology of the former. In the year 1870 the author, in conjunction with Mr. G. F. Matthew, read before the meeting of the American Association in Salem, a paper entitled, "Remarks on the Age and Relations of the Metamorphic Rocks of New Brunswick and Maine," in which, after a brief review of the formations identified up to that time in the Province, the extension of certain of these formations into the State of Maine was pointed out, and their bearing upon the probable age of other groups was discussed.

The formations regarded as thus common to the two countries were these, viz.:—

(1.) A series of coarsely granitoid and obscurely gneissic rocks, crossing St. Croix River in and about the town of Calais, and which were supposed to be of Laurentian age.

(2.) Red Granites regarded as probably representing altered sediments of Upper Silurian or Lower Devonian age.

(3.) Several bands of slates and sandstones, in part micaceous, which rested upon the granites, and were regarded as including both Silurian and Devonian horizons.

(4.) To these, finally, were to be added the Red Sandstones and Conglomerates of St. Andrew's and Perry, containing a distinctively Devonian flora.

In these comparisons, however, only that portion of Maine bordering upon St. Croix River was included, the country north of the sources of the latter not having then been made, in New Brunswick, the subject of examination. Some years later, a

partial revision of the geology of northern Maine was made by Prof. Hitchcock in an article accompanying an atlas of Aroostook County; but this was based upon no new examination of the district, and in the main adhered to the views previously expressed in the report of 1862. In 1878, an Atlas of the Maritime Provinces was also published by Roe Brothers, of St. John, in which the geology of the western frontier of New Brunswick, in common with that of the entire Province, was summarized by Prof. J. Fowler, and represented in a new geological map, but like the publications previously named, this also was based upon observations previously made by others, and contained no new results of original investigation. More recently, observations of a more or less desultory kind have been made by various observers in and about Passamaquoddy Bay, by far the most important being those of Prof. N. S. Shaler, who in a preliminary report addressed to the Director of the United States Geological Survey, but published in the 'American Journal of Science' (July, 1886), details the results of several months' observations about Eastport and the adjoining bays and islands; such report, though only tentative, serving to add materially to our knowledge regarding the structure of the latter and the fossiliferous strata which they embrace. In the meantime, and at various periods between the years 1870 and 1887, the work of the Geological Survey in New Brunswick has been extended up the valley of the St. John and along the entire length of the Maine frontier, and some of the results and comparisons thus suggested have been made the basis of communications already published in the Transactions of this Society, as they have also been made the basis of a review of New Brunswick geology, by Dr. Ells, in a pamphlet published for private circulation in 1887. In the present year the last report and the last map relating to this region will be published by the Canadian Survey, and hence it would seem a fitting time in which to renew our retrospect, and, as far as possible, to correct or to extend the comparisons of twenty years ago.

The importance of these comparisons will be better appreciated when we bear in mind the peculiar position which New Brunswick holds, not only as regards the adjacent portions of Maine, but also as regards the entire State and, indeed, a large part of New England. Situated directly to the east and north-east of the State first named, the north-easterly trends, which here as elsewhere characterize most of the formations of the Atlantic sea-board, cause these necessarily to pass directly from the one to the other, so that a correct determination of the relations of these formations in either country will go far to make intelligible the structure of that which adjoins it. Moreover, in the case of New Brunswick, it would seem that the disturbances and accompanying metamorphism which have so greatly obscured the geology of much of New England, have been much less severely felt, so that a much greater number of definite fossiliferous horizons may be identified; and the relations of other non-fossiliferous formations to these being determined, a key is furnished for the elucidation of regions in which the data available are less complete and satisfactory. The fact that, in many of these fossiliferous horizons, features are presented, which are widely different from those of the more westerly portions of the continent, and point to a closer affinity with those of Europe, adds further interest to comparisons of this kind, and suggests many interesting questions regarding the early geographical and physical conditions of eastern America, a few of which it is proposed to consider in the present paper.

The subject may, for the present purpose, be best considered by a review of the

different formations as these successively present themselves, from south to north, along the international boundary.

At the point where this boundary turns northward from the Bay of Fundy, the coast line of the latter is extremely irregular, presenting in particular two deep indentations, of which the larger, Passamaquoddy Bay, lies almost wholly within the Province of New Brunswick, while the second, or Cobscook Bay, is wholly in the State of Maine. Both are themselves broken by numerous smaller indentations, but this is especially true of Cobscook Bay; while between the two is what is practically a long, narrow peninsula, the larger part of which, known as Moose Island, and supporting the town of Eastport, is separated from the mainland only by a narrow channel. Across the mouth of Passamaquoddy Bay, and separating it from the Bay of Fundy, is a chain of islands, of which Deer Island is the most considerable, while off that of Cobscook Bay, but stretching eastward and partly overlapping as a parallel belt to that of Deer Island, is the still larger Island of Campo Bello.

The geology of Passamaquoddy Bay was first worked out by the writer, in connection with Mr. G. F. Matthew and Mr. R. W. Ells, in 1870-71, at which time it was shown that this indentation is upon three of its sides, the eastern, northern and western, the latter including Moose Island, bordered by a series of but slightly inclined rocks, of which one portion, the lower, was composed of siliceous slates and sandy shales, containing fossil shells, while the upper was to a large extent of volcanic origin, embracing diorites, with associated red and purple sandstones, amygdaloids and felsites; both being at various points covered unconformably by the coarse red conglomerates of the Perry series, then regarded as Lower Carboniferous. Similar fossils were collected from Broad Cove and Shackford's Head on the west side of Moose Island, and from the latter, as identified by the late Mr. Billings, the whole series, described in the New Brunswick reports as the Mascarene series, was referred to the Upper Silurian. At the same time the rocks of Deer Island, consisting largely of slates, with intercalated masses of diorite, and which, by a fold, were supposed to be repeated in Campo Bello, were found to lie unconformably beneath the Silurian and, from the evidence of facts seen farther east, were described and represented on the maps as Pre-Cambrian. Finally, of the smaller islands between Deer Island and Campo Bello, and which differ greatly among themselves, some were referred also to the Pre-Cambrian, but the larger part to either the Silurian or the Lower Carboniferous.

In his more recent examination of Cobscook Bay, Prof. Shaler also recognizes the existence here of two separate formations, which he designates respectively as the Cobscook series and the Campo Bello series, of which the latter is regarded as lying immediately below the former. While, however, the rocks of the Cobscook series everywhere yielded to him as to us an abundant harvest of fossils—those of some localities being of a distinctly Lower Helderberg type, while at others they were rather of the age of the Clinton and Niagara—the rocks of Deer Island and Campo Bello, after the most careful search, failed to yield any. The latter are, by Prof. Shaler, compared directly with the Cambrian system, and are said to nearly resemble the rocks of that age about Cambridge and Boston; but when we recall what is now known of the Cambrian of southern New Brunswick, both as regards the persistency with which its peculiar features are retained, and the remarkable fauna which it yields, it seems hardly possible that this view can be a correct

one. Until therefore more definite evidence is obtained to the contrary, it would seem best to adhere to the view adopted in the Survey Reports that these rocks are Pre-Cambrian, and presumably Huronian, being an extension westward of beds which traverse large portions of southern New Brunswick, and which are at various points overlaid by fossiliferous Cambrian rocks. From the character of the rocks of the Cobscook (or Mascarene) series, Prof. Shaler infers that they were deposited, probably, at no great distance from land, along the eastern side perhaps of a ridge of Laurentian rock stretching up along the eastern sea-board of America and separating the Silurian rocks of this region from those formed in warmer waters on the western side of the same ridge, and north-west to Anticosti. We shall have occasion presently to refer to this conjecture again. Finally, it is important to observe that the facts are such as to indicate that the Campo Bello and Deer Island rocks were subject to extensive elevation and erosion prior to the deposition of the Cobscook series, as this in turn was largely removed before the deposition of the rocks of Perry.

As regards the so-called Perry Group, although recognized by all as the most recent of the formations bordering Passamaquoddy Bay, considerable doubt has been entertained with regard to its precise position. In its fossil flora, so well described by Sir William Dawson, its aspect is undoubtedly Devonian, but to the other rocks of that system as seen only a few miles to the eastward along the New Brunswick coast, it bears no resemblance whatever, while, both in the nature of the beds and in their relations to the subjacent formations, it does bear much resemblance to the rocks of the Lower Carboniferous system which spread so widely over other portions of the Province. For this reason it was, in the Survey Reports and Maps, represented as a part of the last-named system. On the other hand, however, it differs from the latter in the total absence of the marine limestones and gypsiferous beds usually found in connection therewith, and in this respect approaches more nearly a group of coarse sediments skirting the shores of the Bay des Chaleurs, and which have been there shown to be unconformably overlapped by the Lower Carboniferous or Bonaventure rocks. It is probable that in both instances these coarse red beds, though true Devonian, are to be regarded as representing the most recent portion of that system, and like the Catskill Group of New York, which they nearly resemble, constitute a transitional series between the two.

The great bulk of the Perry beds, their coarse character and their contained plant-remains are a further indication of the extensive erosion to which the region has been subjected; while their intersection (at Joe's Point, near St. Andrew's and elsewhere), by dykes of trap, extending across Passamaquoddy Bay, shows that, as in earlier periods, the region continued to be one subject to igneous overflows at least as late as the close of the Devonian age.

In passing northward along the western side of Passamaquoddy Bay, towards St. Croix River, the Perry rocks are found to rest upon a broad platform of granitic and syenitic rocks, extending, with few exceptions, almost to the town of Calais. On the eastern shore of St. Croix River they are more completely covered by Silurian rocks, but still rise into prominent hills, forming a portion of an extensive tract of such rocks extending eastward through Charlotte County, New Brunswick. These rocks, as seen in Maine, are regarded by Prof. Shaler as probably Laurentian. A similar view was also entertained and published as regards those of the Province (Report of Progress, Geol. Sur-

vey, 1870-71), but as there was reason to believe that much of the granite found in this region was of intrusive origin, and of much later date, while the separation of the two was extremely difficult, it was thought best to represent them upon the maps simply with reference to their lithological aspects. It is the belief of those who have studied the geology of Charlotte County, New Brunswick, that in the great axis of crystalline rocks intervening between the Bay of Fundy and the central coal basin of the Province, both Laurentian and Huronian rocks exist, the former being represented not only among the syenitic and gneissic rocks which cross St. Croix River at and below Calais, but also in the limestones and associated beds which directly skirt the Bay at Frye's Island and L'Etang; while the Huronian, besides including the rocks of Deer Island and Campo Bello (with the southern half of Grand Manan), is also represented by bands of dioritic and serpentinous rock, flanking the granites and syenites on their northern edge in the vicinity of St. Stephen. The existence of these old and firm ridges and platforms of Pre-Cambrian rock in southern New Brunswick and Maine, during the deposition of the Silurian and Devonian ages, goes far to explain the contrast which these latter here exhibit, both in character, attitude and organic remains, as compared with those of the regions farther north, to be presently noticed.

We have now to consider the rocks which either cross or are nearly adjacent to the international boundary, along that portion of the latter which lies north of Calais and St. Stephen, extending thence to the frontier of Quebec. Through this extensive tract, including a distance of two hundred and fifty miles, the rocks which actually cross the border are, so far as merely lithological characters are concerned, mainly reducible to two principal kinds, viz., granite and slate, the first named forming a belt some twenty miles in breadth, which crosses St. Croix River just north of Vanceboro, while the slaty rocks occupy the areas respectively south and north of the latter. The general structure also would, when viewed as a whole, appear to be quite simple, the granite constituting an axis on either side of which the sedimentary beds are repeated in corresponding order, rising to and including the beds of the Carboniferous system. Nevertheless, great diversity of opinion has existed, and still exists, as to the precise age of different portions of these slaty rocks, which, both in Maine and New Brunswick, have been severally referred to very different horizons. This uncertainty arises from various causes, but mainly from the fact that, the rocks being of very uniform character over extensive areas and through considerable thicknesses, the recognition of definite horizons through lithological differences is very difficult, while the fossils are but few and obscure, the slaty cleavage by which the beds have been everywhere affected having tended to obliterate them, as they have also largely the planes of sedimentation. The whole area has also been subjected to extensive plication and probably abounds with faults, the position and effects of which are not always easily ascertainable.

We may now consider somewhat further the different views which have been advanced as to the precise equivalency of different portions of these slaty rocks, beginning with those which, in New Brunswick, occupy the interval between the southern and the northern granite belts.

All observers, at least since 1862, have recognized here a division of the slates into two groups. These, in the Report and Map of Prof. Hitchcock were separated solely on lithological grounds—the one adjacent to the granite and presumably the older being

designated as mica schist, while the other, forming the centre of a synclinal, was designated simply as clay slate. The division in New Brunswick was similar, but in connection with both groups, fossils were obtained, those connected with the former, which was described as the "Dark Argillite Series," indicating a Silurian horizon, while those of the latter, though obscure, favored the supposition that they were Devonian. This latter view also received confirmation from the fact that these rocks would thus be occupying their natural position directly beneath the Carboniferous system, around both margins of which they come to the surface. No reason for doubting this determination, as regards the Devonian, has since arisen, but as regards the so-called dark argillites, while at first the view was entertained that they were wholly Upper Silurian, a question subsequently arose as to whether they might not also embrace still older or Cambro-Silurian strata. The rocks with reference to which, more particularly, this latter view was held are those which cross St. Croix River, north of Baring, and thence extend easterly through the parish of St. Stephen, in New Brunswick, to and beyond the settlement of Moore's Mills, consisting chiefly of fine-grained gneisses, micaceous, garnetiferous and staurolitic slates, black plumbaginous schists, actinolyte schists and purple fine-grained micaceous sandstones; but eventually the same view was extended to the whole of the "dark argillite" series, except such portions as could be clearly shown, upon palæontological evidence, to be Silurian. It was, however, at the same time stated that this arrangement was provisional, and it is still uncertain how much, if any, of the formation in question can really be regarded as older than the system last named. The facts which favor the general Upper Silurian age of the belt are those of its position directly beneath and in apparent conformity to the "pale argillites" or Devonian (the contacts, however, being vertical), and of a general resemblance, which it bears to the first-named group of rocks, as developed in some portions of King's County, New Brunswick, and around Passamaquoddy Bay. On the other hand, the resemblance to the rocks which occupy a similar position on either side of the northern granite axis is still more marked; while in this latter case, it has not only been shown that the argillites in question are unconformably covered by fossiliferous Upper Silurian beds, but in places themselves contain fossils indicative of a Lower Silurian horizon. That the rocks of these several dark argillite belts, as seen (1) north of Baring and St. Stephen, (2) through the parish of Prince William, and (3) in Canterbury, New Brunswick, are essentially alike, would probably be readily admitted by any one who directly compared them, and the view that they are the same formation brought up by successive geanticlinals has been taken alike by Gresner, Robb, Hitchcock, Hind, Logan, Ells and the present author. All these authorities have also regarded them in the main as older than Silurian, the two authorities first named considering them (together with the pale argillites or Devonian) as of Cambrian age, while by Hind and Logan they have been compared to the so-called Quebec Group. It should not however, be overlooked that at one point in New Brunswick (Rocky Brook, on Nashwaak River) in the very heart of the dark argillite belt, and at but a short distance from the granite, fossils indicative of a Lower Helderberg horizon were, some years ago, found by the late Chas. Robb, and more recently, in the same belt, but in its less altered portions, fossils which appear to be of Devonian type have been obtained, a few miles north of Fredericton, by Mr. W. T. H. Reed. Hence the same question arises, here as nearer the coast, whether, upon the evidence of these fossils, the age which they indicate is to be regarded as that of the entire belt in which they are obtained, or of any

considerable part of it, or whether, on the other hand, the fossil-bearing bands are not rather to be regarded as portions of newer formations enfolded among strata really of much greater antiquity. The resolution of this question, upon which some further facts will presently be stated, is one of the most important problems still demanding the attention of those interested in New Brunswick geology.

It is necessary now to refer more particularly to the grounds upon which the rocks skirting the northern side of the northern granite axis are, in part at least, held to be of Cambro-Silurian origin. Of these evidences the first, that of unconformability to the Silurian, may be seen anywhere along the line of contact between the two formations, and is evidenced alike by discordance of dip, by transverse progressive overlap, and by the composition of the conglomerates of the newer series. Within a few miles of the border are beds of coarse and highly calcareous conglomerates, conforming to the Silurian succession, and filled with pebbles derived from the Cambro-Silurian rocks near by, and across which their trends would carry them. The evidence of fossils is at present confined, so far as the western portion of New Brunswick is concerned, to the occurrence, first observed by Matthew, of linguloid shells in black calcareous and siliceous beds upon the Beccaguimic River in Carleton County, and which have since been found to be associated with trilobites of the genera *Harpes*, *Trinucleus* and others, indicating an horizon which is certainly Ordovician ; while in the north-east of the Province, in what are believed to be rocks of the same group, remains of graptolites, apparently Lower Silurian, were observed by Mr. Ells. To these facts it may be added that in the occurrence of bright green and red slates, such as occur near Woodstock and Newburgh, New Brunswick, and the association with these latter of heavy beds of coarse grey grit, similar to those of the Sillery formation, a general resemblance is suggested to the rocks of the so-called Quebec Group, as seen along the Temiscouata Portage Road, and the south shore of the St. Lawrence. It is not improbable that the slates of Waterville, Maine, containing the so-called *Nereites*, etc., may be a part of the same great belt.

It has been usual to regard the granites upon which the slates last described repose as being of Devonian age, chiefly upon the ground of their evident resemblance to the granites of southern New Brunswick, and the fact that pebbles, apparently derived from the latter, are abundant in the Lower Carboniferous conglomerates, while they are rare in those of earlier formations. In neither district, however, are the granites known to actually invade undoubted Devonian sediments, whereas such invasion in the case both of the Cambro-Silurian and Silurian, has been frequently observed. The Silurian conglomerates of the north also include both granitic and syenitic pebbles.

The line of contact of the Lower and Upper Silurian, referred to above, crosses the international boundary not far from the Monument at the extreme source of St. Croix River. From this point northward in New Brunswick, the admirable section afforded by the valley of St. John River, running parallel with and for a considerable distance actually forming the boundary, has, with a single exception (that of a narrow belt of Carboniferous and possibly in part Devonian sediments, a few miles north of Woodstock), failed to show the existence of any rocks other than those of the Silurian system. At the same time it was here, as elsewhere, found very difficult, owing partly to the comparative uniformity of the beds, partly to the general and excessive plication to which they have been subjected, and partly to the paucity of fossils, to determine with any degree of

certainty either their order of succession, their thickness, or their exact horizon. In attempting to solve these questions it occurred to the author that some valuable information might be gained by instituting comparisons between the succession of beds upon the extreme southern and the extreme northern edge of the general Silurian basin, the one being found on the Beccaguimic River, in Carleton County, and the other on Lake Temiscouata, in the Province of Quebec. With a view at the same time to the more ready recognition of any Devonian strata which the region might contain, examinations were made in portions of northern Maine, more particularly in the region of the Fish River Lakes and that of Aroostook River, in both of which such Devonian strata had been represented as occurring. These comparisons proved unexpectedly interesting by showing not only that large tracts of what had, in the maps of Maine, been represented as Devonian were in reality Silurian, but that, both in the character and succession of the beds, as well as in the associated fossils, these three widely-separated localities exhibited such a close parallelism as to leave little doubt of their essential synchronism. Some of the facts bearing upon these comparisons have already been given in the Transactions of the Society, but more recently much further information relating to the same subject has been obtained, so that we are now in a position not only to correlate, with some degree of certainty, the several divisions of the Silurian system as seen through the extensive tract extending from Cape Gaspé to northern Maine, but also to compare the nature and origin of these several subdivisions with those of the same formation in southern New Brunswick.

Of the three localities to which reference has been made, the most interesting and instructive is that of Lake Temiscouata, and may well serve as a basis of comparison for the entire region of which it forms a part. As indicated in the sections given in the "Geology of Canada," the strata here exposed fall naturally into three great groups, the first consisting essentially of limestones, more or less pure, and abounding in fossils, but having at their base a considerable thickness of grey and white sandstones, with some conglomerate; the second consisting largely of sandy shales, but having beneath them over 1,000 feet of coarse conglomerate (Burnt Point conglomerates), and at their summit heavy beds of coarse somewhat epidotic sandstones (Point aux Trembles sandstones), and thirdly, an apparently great thickness of very fine slates and sandstones, the latter occupying all the lower half of the lake, and spreading widely over northern New Brunswick. The attitude of these groups is as strongly contrasted as is their character, the rocks of the first or Mount Wissick division having but a low inclination (varying from 13° to 30°), while those of the second have a much steeper, but at the same time very regular dip of about 60° to the southward, while those of the third, exhibit only a system of abrupt and complicated foldings. Actual contacts between the several divisions are not visible; but from the circumstance that in all three the general dip is to the south, and further that the rocks at the base of Mount Wissick rest directly and unconformably upon beds of the Quebec group, it was, in the author's first paper upon the subject (Trans. Roy. Soc. Can., Vol. IV) suggested that these were probably the lowest beds, and that those of the second and third divisions followed the order of their apparent succession. It was, however, at the same time stated that until a more complete examination had been made of the fossils collected, not only from Mount Wissick, but from Point aux Trembles, no definite conclusions upon this point could be reached. Since

the time, much more ample collections have been made and have been examined by Mr. Whiteaves and Mr. Ami, but with the result of showing that while the Mount Wissick rocks, as had been supposed, are in the main decidedly Lower Helderberg in age, those of Point aux Trembles indicate a lower horizon, approximating more nearly to that of the Niagara and Medina formations. This conclusion, which is confirmed by evidence seen elsewhere, is most important, for not only does it indicate that the order of succession of the strata in this vicinity is, as regards two at least of its divisions, the reverse of what had been supposed, but that a great physical break, accompanied by unconformity, exists here between the lower and upper half of the Silurian system itself. Further, from the position and low inclination of the Mount Wissick beds, and their entire absence from the region west of Lake Temiscouata, it would follow that the entire mass of this group, of nearly 600 feet in thickness, has been completely removed from an area of great extent.

Taking now the rocks of the Temiscouata section as the key to the Silurian system of eastern Quebec, no difficulty is found in identifying the rocks of Mount Wissick with those described by various observers between the latter and Cape Gaspé. Thus, the peculiar white sandstones, which form so conspicuous a feature at the base of the eminence named, though apparently wanting in the typical section at Cape Gaspé, are readily recognizable at many other points in the Gaspé Peninsula, such as the sources of the Chatte and Matane Rivers, at Lake Metapedia, Grand Metis River, the Valley of the Neigette and Rimouski River, and in each instance are directly overlaid by a great body of limestones, of which the fossils in the lower part belong to the upper portion of the Niagara formation, and from this range up to and through that of the Lower Helderberg Group. They also rest, as at Mount Wissick, directly but unconformably upon the rocks of the Quebec Group, with no trace beneath either of the heavy conglomerates of Black and Burnt Points, or of the fossiliferous slates and sandstones of Point aux Trembles and Tuladi River. On the other hand, in a westerly direction, while these inferior beds may be followed for several miles from Lake Temiscouata, the higher calcareous members in turn disappear, being apparently cut off abruptly in the eminence of Mount Wissick. The third or slaty division of the system is more persistent, and may be seen with essentially the same characters on Metapedia River, on the Patapedia, the Quatawamkedgewick, the Restigouche, the Madawaska and the upper St. John. Over these extensive areas, the position of the beds is usually that of broad and low undulations, but in places these are replaced, and often quite abruptly, by a high dip or by sharp and complicated foldings. Very similar rocks, with similar variations of attitude, are also spread over a large part of northern New Brunswick and Maine, where their soft and highly calcareous character, combined with a strongly developed cleavage, have determined a district remarkable for the depth and productiveness of its soils. Here, however, in connection with the movements to which reference has been made, there are a few points in which strata resembling the inferior beds of Lake Temiscouata are brought to the surface, and are found to contain a similar assemblage of fossils. One of these is near the mouth of Siegas River in Victoria County, New Brunswick, and directly on the border, where a nearly vertical series of strata consists in part of conglomerates, holding (like those of Burnt Point on Lake Temiscouata) pebbles of limestone, serpentine and jasper; in part of hard grey sandstones, holding besides Orthis and Strophomena (*S. rhomboidalis*) a Zaphrentis resembling a form found in the Point aux Trembles sandstones, and

thin beds of limestone. Through the latter, which are quite peculiar in having the thin layers of which they are composed, not only separated by thin shaly partings, but divided across the layers into numerous partly separated blocks, as though disjointed by the pressure to which they have been subjected, this locality is easily connected with another, in which a similar association of strata may be seen, viz., that of the Aroostook River between Ashland and Presqu'isle. Here again, a series of coarse conglomerates, carrying fragments of serpentine and jasper, in addition to a variety of metamorphic and igneous rocks, is succeeded by heavy beds of sandstone, somewhat dioritic and vesicular in aspect, and these by slates holding limestone layers in every way similar to those of the Siegas. In the sandstones, besides carbonized vegetable remains, are impressions of a coral, resembling Favosites, a Bryozoon, probably a Callapora, Orthis, *Strophomena rhomboidalis*, Rhynchonella, Spirifera (like *S. radiata*, Sow.), *Atrypa reticularis*, Lin., and Cornulites (like *C. flexuosus*, Hall)—the whole indicating an horizon about that of the Niagara formation. Similar conglomerates and sandstones are widely spread over northern Maine, and in the reports upon that State have been regarded as Devonian, but there would now seem to be but little doubt that they are the equivalents of the Burnt Point and Point aux Trembles rocks of Temiscouata Lake, and, with the latter, hold a position which is quite low in the Silurian system. In the same portions of Aroostook County, Maine, the higher members of this system are again represented by limestones, and are remarkable for the number and fine preservation of the organic relics which they hold, the well known beds of Square Lake or Lake Sedgewick having yielded not less than forty-two species, mostly new, while similar beds near Ashland are but little less prolific.

Finally, on Beccaguimic River, in Carleton County, New Brunswick, and on the extreme southern edge of the great Silurian tract of that Province, strata are again met with, which, though highly disturbed, exhibit much the same aspect as those which have been described, with similar relations and organic remains.

It will now be of interest to institute a comparison between the succession of Silurian rocks as thus made out in northern New Brunswick, Quebec and Maine, with the succession of the regions nearer to the Bay of Fundy.

In so doing, one of the first facts to attract attention is the almost entire absence, in southern New Brunswick, of the great belts of limestone which constitute so marked a feature in the north, and more particularly in the Province of Quebec. Indeed no undoubted equivalents of these Lower Helderberg rocks are known to occur in the former, though apparently met with, to a limited extent, in south-eastern Maine, as observed by Prof. Shaler. On the other hand, between the lower members of the system in the two cases a very striking parallelism may be drawn. Thus, taking the section afforded by the Mascarene peninsula, in Passamaquoddy Bay, as typical of the southern coastal region, the grey felspathic and siliceous slates, which constitute its first two divisions, apparently find their counterpart in the great body of slates, often also highly siliceous, which border Lake Temiscouata between Burnt Point and Point aux Trembles, already described as holding a fauna low down in the Silurian system. With the conglomerates of Burnt Point, the latter a local accumulation, they may be regarded as the probable equivalents of the Oneida, Medina and Clinton Groups of New York, of Divisions II and III of the Anticosti series, or of Groups B and B^1 of Arisaig in Nova Scotia. Division III of southern New Brunswick consists of sandstones, of greenish and purplish colours and

more or less amygdaloidal; and similarly, in the north, the beds of Point aux Trembles, on Lake Temiscouata, with their supposed equivalents on Siegas River, New Brunswick, and on the Aroostook, in Maine, occur in similar relations and present much the same aspect, including in both instances the occurrence of much comminuted vegetable matter. Division IV of the Mascarene section, consists of red and green slates and sandstones, with diorites and felsites, and so, again, similar rocks are found in this position at Cape Gaspé, Cape Chatte, Metapedia Lake, Rimouski, and near the base of Mount Wissick. The felsites and associated trappean rocks of Aroostook County, Maine, as well as those of Restigouche County, New Brunswick, may possibly represent this and the succeeding division (V); but the facts at present known, rather favor the idea that the former are Cambro-Silurian. The absence of the higher members of the system in southern New Brunswick may be accounted for upon the supposition that the barrier of Laurentian rocks, alluded to on a former page, as extending along the coast subsequently to the close of the Archæan age, continued to exist in Silurian times, and that while, in the north, the later half of the Silurian age was a period of subsidence, in the south it was chiefly one of elevation, excluding the access of pure sea-water, and hence, of such forms as are dependent on its presence.

Of other strata observed in northern Maine and New Brunswick, it is more difficult to speak with confidence, their stratigraphical relations not having been fully worked out, and fossils being as yet wanting. Of these the most important consist of a mass of fine grained slaty felsitic and siliceous rocks, associated with dioritic and amygdaloidal sandstones, quartz-porphyries and agglomerates, which appear to stretch in parallel belts across a considerable portion of Aroostook County, and in places rise into prominent hills. One of these belts is conspicuously exposed about Churchill, Umsaskis and Spider Lakes on Allegash River, and apparently extends thence past the head-waters of the Aroostook, forming the Aroostook Mountains, and eastward to the Valley of Fish River, separating the Silurian basin of Square and Eagle Lakes from that of Ashland and Presqu'isle; while a second, as yet only seen at a few points, lies to the south of the latter, here including the steep and conspicuous conical peak known as the Haystack. No fossils have yet been observed in the slates of this group (referred to in the Maine reports simply as trappean rocks), and we are hence without definite proof of their age, but the nature of many of the pebbles in the Silurian conglomerates would seem to indicate that the former was the source from which these were to a large extent derived, while there are also points in which conglomerates, apparently Silurian and similarly constituted, have been seen to rest unconformably upon the siliceous and felsitic rocks. On the other hand, these latter, in their fine-grained flinty texture and banded aspect, as well as in their dark purple to black colours, recall the similar beds which, in southern New Brunswick, mark the base of the Silurian system. If really more ancient than the latter—as seems most likely,—their true position is probably that of the Cambro-Silurian formation, to some portions of which they also bear much resemblance. The same remarks will also apply to a series of fine grained micaceous and gneissic sandstones and slates, of dark purplish and lilac colours, which accompany the beds above described on the Allegash River. These latter are peculiar in being filled with imperfectly developed crystals, apparently of staurolite, and are quite similar to some of the beds referred to on a former page, as occurring along the course of St. Croix River, both near St. Stephen, and again in the western

part of York County, New Brunswick. A further examination of these doubtful beds is greatly to be desired.

Of true Devonian, none is known to occur in the immediate vicinity of the frontier, unless it be a small band of dark grey and reddish conglomerates and shales, holding remains of Psilophyton, which crosses St. John River, a few miles above the town of Woodstock. While, however, as has been stated, much of what, in the Maine reports, has been described and mapped as Devonian, is now known to contain a fauna quite low down in the Silurian, the determinations of Mr. Billings of the collections submitted to him would appear to indicate that strata bearing true Oriskany forms do occur at various localities (such as Parlin Pond and elsewhere), in the northern part of the State, while an outlier of similar age has been observed by Mr. W. McInnes, near the head of Tobique River in New Brunswick.

Upon the roads leading south from the town of Presqu'isle, in Aroostook County, and not far from the border, the Silurian rocks are unconformably covered, over a small area, by a series of bright red and rather soft sandstones and conglomerates. It is possible that these may also be Devonian, the equivalents in that case of the beds of Perry, but in the absence of fossils it seems altogether more probable that they are Lower Carboniferous, representing the very similar beds of that age, which occur in a like position in the valley of Tobique River, in New Brunswick. The absence, so far as known, of strata of like age and origin from points further westward in the State of Maine, would appear to indicate that the area of marine submergence in the later Devonian and Lower Carboniferous ages, the westward extension of the great St. Lawrence or Acadian Basin, had its western limit not far from the boundary line now separating New Brunswick from the United States.